I, __________ BIKRAMADITYA BASU ___________, hereby submit this work as part of the requirements for the degree of:

Master of Science

in:

Civil Engineering

It is entitled:

Accelerated Construction and Rehabilitation of Bridges

This work and its defense approved by:

Chair: ___Dr. O. SALEM_______________

___Dr. R. MILLER_______________

___Dr. A. GENAIDY_______________
ACCELERATED CONSTRUCTION & REHABILITATION OF BRIDGES
Accelerated Construction and Rehabilitation of Bridges

A Thesis Submitted to the
Division of Research and Advanced Studies
of the University of Cincinnati

in partial fulfillment of the requirement for the degree of
MASTER OF SCIENCE
in the Department of Civil and Environmental Engineering
of the College of Engineering
2005

by
Bikramaditya Basu
B.E Bangalore University, India. 2002

Thesis Committee Chairman:
Dr. Ossama Salem
ACKNOWLEDGEMENT

I would like to dedicate this thesis to my parents and grandparents.

I remember everyone who makes up “notyetone”- my source of sustenance in Cincinnati.

My special thanks to my professors, Dr. Salem, Dr. Miller and Dr. Genaidy.
Abstract:

The growing traffic demands and an aging transportation network necessitate highway construction to initiate and intensify efforts to accelerate repair and rehabilitation. Statistics show that vehicle miles have grown by 80% between 1982-2000 while the lane miles increased by only 3.8% during the same period. Any effort to close or restrict the highway for repair and rehabilitation work leads to unsafe conditions and major traffic delays.

Extensive research has been conducted in various aspects of accelerated construction. Surveys have been conducted to identify factors for the success of different innovative contractual agreements. The contracts that were looked at for this work were design build, incentive/disincentive, A+B, warranty and Lane Rental. Research on accelerated construction has focused on the overall aspect of implementation of such concepts. This thesis however deals exclusively with the execution of the accelerated construction initiative by the Ohio Department of Transportation.

Three bridges constructed under the initiative were chosen for study and research. The construction of the bridges, the ones in Guernsey, Clinton and Montgomery counties were observed by visiting the construction site, attending the pre and post construction meeting. These bridges used prefabricated post tensioned bridge decks. Data and information collected at the site and by interaction with different people associated in different capacity through the construction process was put together. The bridges in Clinton and Montgomery counties were compared because of the intrinsic similarity with the projects. Both were constructed using similar techniques and by the same contractor. One was a success and other not. The comparison revealed that small changes in the construction and planning were reflected in a substantial difference in project success.
The conclusions and recommendations were based on the experience and understanding of the accelerated construction initiative. It showed that some of the areas that need to be worked on and improved upon for the project success are planning, changing of the existing mindset and other administrative issues and not technical aspects.
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Chapter 1

Introduction

Introduction & Problem Statement

“The highway network is the backbone of America’s transportation system, making it possible to meet the mobility and economic needs of communities, regions, and the nations as a whole. Americans use the highway system to make than 90 percent of passenger trips and move 6 percent of total freight volume; highways also accommodate buses, bicycles and pedestrians. In addition, highways provide vital links among all modes of transportation; thus the influence of their physical and operations condition extends well beyond the impacts experienced directly by highway users.” (1)

The primary focus of the construction industry in the twenty-first century is infrastructure: to build new infrastructure projects in developing nations and rehabilitate and maintain the existing infrastructure in developed nations. Clearly, bridges are an integral part of every nation’s infrastructure.

Like most other industries, the construction industry is confronted with issues of delays and high costs of delivery. In my research work, I plan to address the issues of time and cost of construction work in relation to bridge construction.

The US transportation system is a mature system with most of the needed infrastructure in place. As a result, future infrastructure improvements are likely to be major upgrades and/or replacements of existing systems rather than construction of new systems. Much of the US highway system is aging, and because they were built 30-50 years ago, are in need of major repair, rehabilitation and replacement. Ironically, the highway capacity has remained virtually
unchanged during the past several decades, and has seen a steep rise in the volumes of traffic and high levels of congestion.

Putting it in perspective: FHWA

The increase in traffic demand (1982-2000).

- Vehicle miles of travel increased by 80%
- Licensed drivers increased by 31%
- Lane miles increased by only 3.8%

An aging system:

- 40% of all bridges are more than forty years old.
- When these bridges were constructed design life was often only 50 years.
- Most pavement designs have a 20 year life expectancy.

Traffic volumes are so high that any attempt to close or restrict the highway for construction results in unsafe conditions and major traffic delays. Traffic delays due to detours or slow traffic due to blocked lanes introduce a real time cost component. Since the real costs are impacting motorists due to lost time, extra fuel needs, and lost revenues, more focus is being placed on bringing the infrastructure back in use as soon as possible. This has ushered in an age of using accelerated techniques in the reconstruction of damaged or destroyed elements of America’s infrastructure. It is a whole new way of looking at infrastructure reconstruction using varied methods and resources to speed up the process.

Bridges are a major problem as they tend to take the longest to construct. In addition to this, bridges are susceptible to terrorist strikes, attacks during war, and impairment due to environmental factors. If any of these factors put a bridge out of service, it could take a very
long time to restore the bridge using current methods of construction and contracting. Another particular problem with bridges is that, unlike highways which need not be completely closed down during repair or rehabilitation, the same work cannot be performed on bridges one lane at a time or by allowing traffic to use the median or introducing an additional, temporary lane. Part of the problem is that bridge designs and specifications create situations that slow down bridge construction. Take, for example, a simple deck replacement. Because the decks are cast monolithic, the old deck must be cut into pieces for removal. ODOT does not currently allow the use of stay-in-place forms, so the new deck must be formed - quite a time-consuming process. Current specifications do not address rapid curing materials, so conventional concrete with a 7 day wet cure is still used. When half-width construction methods are used, the construction time is further increased. The result is that a deck replacement may take several weeks to complete with traffic restrictions during the entire period of construction.

Thus, there is a need to find ways to improve the speed of bridge construction.

Facts about Ohio (ODOT)

1. 34th largest state in US in terms of geographical area.
2. 10th largest highway network.
3. 4th largest interstate network.
4. Has 16 urbanized areas second only to California and Texas.
5. 2nd largest number of bridges.
6. Ohio has 42,000 highway bridges.
7. ODOT is responsible for 14891 bridges on the state highway network.
8. There are 23 bridges which connect Ohio with neighboring states.
Need for Research:

*Bridge Construction:*

- There is a need for more bridges due to the increase in traffic volumes and congestion and this warrants greater research in this field.
- Every bridge is unique in terms of design and construction. Thus the construction process is complicated which demonstrates a need for research on bridges.
- Construction work is very lengthy so there is an apparent need to introduce innovative techniques for lean construction.
- Construction work is very expensive and thus research is needed to bring down the construction and repair costs.

*Bridge Repairs:*

- Most of the bridges have been built a few decades back so there is an imminent need for repairs and rehabilitation thus a need to study the same.
- Bridges are most vulnerable during war or terrorist strikes. So it is important to device ways to quickly repair bridges so that men and materials can again be easily moved across.
- Even during adverse climatic conditions like hurricanes, typhoons and earthquakes bridges are affected so the need to study bridge repairs.

**Advantages of Accelerated Construction:**

- Reduce the time taken for construction
- Increase safety and mobility
- Reduce environmental, social and economic impacts
- Increase construction quality and efficiency of operation
Background:

A thorough search of the total body of literature on the ASCE journals have shown that not much has been studied or worked on in the field of fast track bridge construction and rehabilitation. There are numerous articles in the field of fast track construction and design build construction. Chan and Hi tried to develop a list of success factors for design build construction. These success factors were developed after a detailed feedback through a questionnaire that was distributed amongst contractors and owners. A good understanding of fast track construction was offered by Williams. It helped in analyzing some of the pit falls associated with fast track construction and how best to overcome them. It was noted that some of the primary areas of difference between the traditional type of construction and an accelerated construction were schedule, design, materials, cost and the people associated with the projects. In fast track construction conditions alter along every stage of the construction process. Thus there is a need for constant planning and decision making and idea which was offered by Pena-Mora and Park in their article “Dynamic Planning for Fast Tracking Building Construction Projects.” It talked about the inherent dynamic nature of the fast tracking and how best to work it towards making the project a success. Pena-Mora collaborated with Li to publish a paper titled “Dynamic Planning and Control Methodology for Design/Build Fast Track Construction Projects.” In this paper the authors proposed a methodology to help create a dynamic project plan for design/build fast track projects. Incorporating unforeseen circumstances or problems that may be encountered during the project execution into the schedule and the planning process did this. Shah’s paper “Innovative design/build approach: the Ambassador Bridge Project” focuses primary on the reconstruction of one of the country’s most important bridges. The contractual agreements, the incentive package for the contractor, the tough schedule and other aspects of the bridge
construction project were discussed in the paper. Through this research it will help to bind together theories of fast track and design build construction with bridges construction.

**Objective:**

The purpose of this research is to identify and share practices within the Ohio Dept. of Transportation that are either hurtful or conducive towards reducing the project delivery time. In addition, this work aims at providing a basic and clear understanding of accelerated construction and its implementation with regard to bridges. Construction techniques like innovative contracts and innovative construction materials are being used by the state DOTs. However there is no fixed or perfect way for accelerated construction. Every state adopts different procedure for accelerated construction. This work deals with the accelerated construction initiative in Ohio and the basic objectives of the study are as follows.

- Study accelerated construction methods
  - Innovative construction methods
  - Innovative contracts

- Determine if any chosen method reduces bridge construction downtime

- Study the ODOT’s Strategic Initiative # 9 project to build bridges “Faster, Smarter & Better”

- Identify areas of improvement for implementation of such projects in the future.

- Propose to ODOT any change in approach to build bridges “Even Faster, Even Smarter and Even Better.”

**Methodology of Research**

The methodology I followed for the research is as follows:-
- Conduct a comprehensive literature survey
- Study contractual methods chosen by DOTs & State Highway Agencies (SHAs) for accelerated construction
- Observe and take notes on the construction of three bridges under SI # 9
- Visit the construction sites and post construction meetings and interact with the project manager and the ODOT site engineer to understand the issues better.
- Study the :-
  - Materials and their procurement
  - Manpower Management
  - Scheduling, Planning and Progress of construction and repair work
  - Innovative techniques and materials that can be implemented

**Organization of Thesis:**

The thesis has been organized into six chapters. In the first chapter the topic of study is introduced. The second chapter dwells on the literature research conducted on the topic. This chapter analyzes various innovative construction techniques and also the research that has already been performed in the area of accelerated construction. The third chapter is on the first bridge that was constructed as part of the Strategic Initiative #9 of the Ohio Department of Transportation in Quaker City, Guernsey County. The fourth chapter deals with the construction of two other bridges. The same contractor constructed these bridges and using similar methods and it offers us a good basis for comparisons. The final chapter is on the conclusions drawn from the accelerated construction initiative in Ohio and I also offer recommendations that can be applied in the state and elsewhere on future accelerated construction projects.
**ODOT’s Accelerated Construction Initiative:**

The Strategic Initiative (SI)-9 aims at building bridges “faster, smarter and better.” Through the initiative, ODOT identified six (6) innovative construction concepts and six (6) innovative contracting methods which could reduce the amount of time a bridge under construction was closed or under lane restrictions ("down time"). Previously, a committee that consists of ODOT personnel, consultants and contractors was formed to study the problem of reduced bridge downtime and identify solutions. The Committee conducted a literature and internet search for possible solutions. They also conducted a survey of contractors. Using the results of these studies, several concepts for speeding up bridge construction were identified:

1) Stay-in-place forms, either steel or concrete;
2) High performance concrete materials with reduced curing times;
3) Prefabricated bridge decks – either precast concrete or concrete filled steel grids;
4) Prefabricated superstructure units, such as steel beams with a prefabricated deck attached;
5) “Deckless” bridges, such as adjacent precast box or bulb “T” beams.

It was also found that bridge sub-structure elements could be prefabricated, thus reducing construction times when a complete bridge replacement or bridge widening is being done. After much deliberation, the Strategic Initiative No. 9 Committee identified six specific concepts which would be suggested to the Districts for use in demonstration projects. The concepts are:

1) Stay-in-place steel forms;
2) Prestressed concrete bridge decks which are match cast, post-tensioned and ground to final profile;

3) Concrete filled steel grid decks;

4) Precast sub structure units;

5) High performance concrete materials which have shorter curing times;

6) Transversely post-tensioned adjacent box beams with integral wearing surfaces ground to final profile and compatible with standard TST-1-99 railings. Precast parapets are to be considered when over the side drainage is not acceptable.

It has been suggested that the concepts listed above can be more effective at limiting the time bridges are closed or under lane restriction if they are combined with innovative contracting techniques. Ohio DOT has identified some promising contracting techniques:

1) Work day contracting - sets the number of construction days to complete a project or portion of a project.

2) Incentive/disincentive - contractors are paid extra for projects or tasks completed ahead of schedule and are assessed deductions for projects or tasks completed behind schedule.

3) Lump-sum incentive - large lump sum payments are used as incentive to meet a specific completion date.

4) Liquidated Savings - contractors are paid an amount to late finish liquidated damages.

5) Design/Build - allows the contractor to create a design which will optimize the construction schedule.
6) A+B - A is the cost of the project, B is the contractors estimate of project completion time. Bids are judged on lowest total "cost" using A + B*user cost/day. B becomes the contract completion time with penalties for late completion.

The specific objectives of the SI-9 project and this study are:

1) Determine if any of chosen concepts result in reduced bridge down time. For this study, the goal is to reduce bridge down time, even if the total project time increases.

2) Determine the cost of implementing these concepts as opposed to conventional construction methods and attempt to determine if any added cost is justified.

3) Assess the applicability of these concepts to different types of bridges and attempt to determine how widely these concepts could be used. Also look for possible limitations of the use of these concepts in terms of things like bridge length, bridge type (simple span vs. continuous), type of highway, geographical location, over water vs. over road, etc.

4) Determine if the implementation of these concepts creates an undesirable situation such as a sole source condition or the need for highly specialized equipment or training which might limit the number of possible bidders.

5) Assess possible long-term performance of these concepts and identify possible maintenance issues.

6) Create a series of decision matrices which will help designers and ODOT engineering and contract personnel determine the most effective construction and contracting concepts for use on a specific job. Since only six pilot projects will be studied, it will not be possible to completely populate these matrices. Therefore, a foundation will be created to incorporate the result for future pilot projects.
Chapter: 2

LITERATURE REVIEW

Innovative Contracts:

Design Build:

Design Build construction has been steadily growing in popularity in past few years. It is a popular contracting method in the private sector, yet underutilized in the public sector. ENR estimates that the current domestic market for design build construction is $74.5 billion with another $9.6 billion in the international market.

Unlike traditional methods of construction, the design and construction of a project in design build is performed by a single company or a joint venture of companies through a single contractual agreement between the contracting agency and the contractor. “This approach provides the government with one source of responsibility for the project. The design-build group shares information throughout the project, beginning with the design phase. The responsibility is centralized in the design-build firm” (Hancher). Many of the benefits of a well-planned and executed design build project—namely improved quality along with considerable savings in time and cost is a result of one party being in charge (Kerness et.al.). “The design build system challenges the traditional plan by saving the owner overall time for a project. This is accomplished by eliminating some of the conflict of having the designer and the builder compete for prospective funds, by combining the two entities it allows for timely communication and creates a point of singular responsibility” (www.ic.usu.edu). Some of the variations to the traditional design build project are as follows:

Bridging: the owner develops preliminary project design to the 30-50% level.
Turnkey: when the owner requires outside expertise and then allows the entity to turn over the keys at project completion.

Design Build Warranty (D-B-W): combines a warranty provision with Design Build.

Design Build Maintain (D-B-M): combines maintenance provisions with Design-Build.

Privatization: when a private entity designs, builds, and maintains a section of roadway in turn for a toll or fee.

The primary objectives of entering into a design build contract are as follows.

- Time savings
- Singular responsibility
- Reduction in administration and inspection costs
- Reduction or elimination of change orders and claims
- Permit maximum contractor flexibility
- Provide expertise that may not be available through conventional methods of construction
- Allow innovation and new approaches that will contribute towards increasing speed of construction and also improving the final product
- D-B-W allows for a warranty provision that assures quality and performance of the product during warranty

Though FHWA has encouraged the state DOTs to try Design Build, it still considers its implementation to be on an experimental basis. “There is however great deal of resistance from the design community which fears that cost will dominate the decision making and result in lower quality designs” (Hancher).
In the past, various studies have been conducted to identify factors influencing design build projects performance. (Ashley et.al 1987) identified forty-six factors and categorized them into five main groups: (1) management, organization, and communication; (2) scope and planning; (3) controls; (4) environmental, economic, political, and social; (5) technical. Based on a study of eight projects with average performance and another eight projects with outstanding performance, they found significant differences between the average and outstanding projects. The differences were in the planning effort in construction and design, project manager goal commitment, project team motivation and goal orientation, project manager technical capabilities, scope and work definition, and control systems. They also found that the planning effort in construction contributed to 87% of the variance of functionality performance, while the project manager’s administrative capabilities accounted for 77% of budget performance variance from the regression results. (Chan et al 2001) conducted survey among clients and contractors who have participated in design build project. The participants were asked to rate the thirty-one factors identified as the ones that contribute to the success of such projects. Six primary factors were extracted from the results and they were (i) project team commitment; (ii) contractors’ competencies; (iii) Risk and liability assessment; (iv) End-users’ needs; (v) constraints imposed by end users. These six factors accounted for 78% of the variance in responses. The first three factors accounted for 26, 16 and 10% of the variance respectively.

One major drawback of design build construction, which was overlooked by most researchers, is that fact that only large construction companies are capable of executing such projects. Smaller companies are incapable of having an inhouse design and construction team. This was evident during the SI#9 project too. For the largest bridge project in terms of duration, money and,
complexity the contract used was design build. In case of joint ventures too, it is usually an association of large and well-established construction and design firms.

Secondly, most of the research conducted to reach conclusions as cited in the above paragraphs was on commercial and industrial projects. Infrastructure projects and design build contracts were never the focus of any research.

Thirdly, factors for success or failure of design build projects are intertwined. It is very difficult to delink or segregate them into different categories as has been done in the studies. Also some factors like contractors competencies as given by Chan as a factor of success is very broad and generalized. In addition most conclusions drawn are from third party opinion, through questionnaires. The authors were never directly involved in the project. The studies definitely give us a fair idea of design build projects but they are not the final word.

**A+B:**

“In addition to new prequalification procedures emphasizing past performance, transportation lawyers have modernized the bid process by providing for innovative approaches that encourage accelerated project delivery. Many states have adopted the A+B bidding.” (Kerness et.al).

A+B Bidding is a cost-plus-time bidding procedure that selects the low bidder on the basis of the combined monetary worth of the contract bid items \((A)\) and the time \((B)\) needed to complete the project. It identifies the additional costs of the construction process besides the amount paid to the contractor. A common formula used for award calculation is: award bid = \((A) + (B \times \text{Road User Cost/day})\). The primary advantage with such a contractual agreement is that it motivates the contractor to minimize the overall time on high-priority and high-usage
projects. It also encourages the contractor to finish early by (1) offering bonuses for early completion and (2) assessing fines for late completion. One concern with such a type of bidding is that nighttime work and accelerated construction may compromise on safety issues and quality of product. Another concern is that disproportionate I/D or time estimates may lead to mathematically unbalanced bids (TXDOT).

Criteria for selecting A+B Bidding with I/D provisions:

- Traffic restrictions, lane closure, or detours result in high road-user costs (RUC). Some agencies specify a minimum threshold RUC level ($2,000-$3,000 per day). If the monetary benefits to the highway user equals or exceeds the contractor’s costs to finish early, the maximum incentive may be earned.

- Safety concerns or significant impacts to the local community or economy during construction warrant expediting the project.

- Traffic control phasing can be structured to maximize a contractor’s ability to reduce the duration of construction.

- The project is relatively free of utility conflicts, design uncertainties, or right of way issues which may impact the bid letting date or the critical project schedule.

- It is in the public interest to complete the project as soon as possible, or by a specific completion date and the agency seeks contractors expertise to facilitate an earlier completion.(www.usu.edu)

In all, twenty-eight States and the District of Columbia (see Appendix B) have thus far used the A+B bidding method under SEP-14. Of these, Maryland, Missouri, Florida, and New York have been the most active users. California used the A+B Method to reconstruct critical bridges that were damaged or destroyed in the Los Angeles earthquake. A 1998 informal FHWA survey
(with thirty-seven responding Divisions) showed eighteen states engaged approximately seventy A+B contracts with I/D provisions in the past year (7).

SEP- FHWA’s Special Experimental Project No: 14 to evaluate innovative contracting techniques. A major disadvantage with using A+B is the role of the road user costs. An universally acceptable procedure to determine the road user cost has not been developed yet. Most DOTs use their own method to determine the RUCs which at times is not consistent.
Procedural Flowchart for preparing A+ B Specifications: (TXDOT)

1. Need for A+B?
   - Calculate estimated project and/or milestone durations

2. CPM Schedule
   - Calculate estimated project and/or milestone durations

- Estimate daily Road User Cost (2)
  - Use discount factor to specify I/D or both. Typical 25%

- CPM Schedule
  - Calculate maximum or minimum number of days allowed for the bidding process

- Define “substantial completion” for award of any incentive

- Prepare A+B bidding specifications
**Warranty:**

This well-known contracting procedure allows the owner verification and assurance of the services to be received. When applied to highway construction, it guarantees that suppliers, makers and contractors assume full responsibility for the work they perform and the necessary repairs or changes if any deficiencies arise. Not only does the contract reduce potential risk factors for the owner, it also creates an incentive for overall project quality and a definite time establishment for the project life. The owner could also opt for a decreased level of supervision on the project. Although the initial cost for a warranty contract may be higher than traditional construction, the payoff is much greater because it results in lower life cycle costs. “The current warranty for almost all government funded projects is the performance bond. This bond provides assurance that the materials and workmanship of the contractor will be good during the project and up to 1 year after project completion and acceptance” (Hancher). Unlike in the US, the use of long-term warranties is a common practice in Europe and other countries for the purpose of assuring high-quality work from the contractor.

Warranty contracts are calculated based on the amount of time the owner expects the structure to perform at an expected level. For example, the owner could seek a year’s warranty with pavements, whereas a bridge warranty could extend for a longer period, typically ten to fifteen years. A crucial component of warranty contracting is that guidelines are reasonable and enforceable. If the guidelines are too restrictive or place undue burden on the contractor, it may be difficult to collect on the warranty, thereby negating any benefits. An additional staffing burden may be placed on the department to ensure the warranties are monitored after completion of the build portion of the project (MnDOT). One outcome of using warranty provision is that the costs are usually higher than using other contractual agreements. The contractors try to
ensure that the product is of the highest quality so that recurring expenses due to repairs during the warranty period is avoided. Unlike other contracts, with the use of the warranty clause the work of the contractor does not end with the end in construction work.

**Incentive/Disincentive:**

An increasing number of state highway agencies (SHA) are choosing the I/D provision in their contractual agreements for repair/rehabilitation of the highways. Incentive and disincentive contracts are used not only to give credit to the contractor for early completion of the project, but also to provide a disincentive for late finish of the project. (Shr 2004). I/D price is calculated on the basis of the implicit or indirect costs that are involved in a construction work such as the length of the contract period and the extent of traffic disruption. The I/D amount must be based on the (1) safety of users; (2) loss of user time due to traffic; (3) increase in gasoline consumption; (4) increased administrative and monitoring costs associated with the use of I/D contracts (Jaraiedi., et.al. 1995). Some variations in the typical I/D contract are the bonus/penalty plan, bonus plan only, penalty plan only. Road-user costs form an integral part of the assessing the I/D for a contract. FHWA conducted a study in 1988 that determined that road user costs were being determined by rules of thumb or personal knowledge instead of being calculated using construction engineering inspection costs, traffic control costs, detour costs, and accident costs for accuracy. I/D contracts are primarily used in projects whose construction would severely disrupt highway traffic or highway services, significantly increase road users’ costs, considerably affect adjacent neighborhoods or businesses, or close a gap, thereby providing a major improvement in the highway system.
“Currently most State Highway Agencies (SHAs) use a fixed amount or fixed percents of construction cost as the maximum incentive. Some states set the limits also referred to as the ‘caps’) as a percentage of the total construction cost; the caps are set mainly by using a value of 5% of the total construction cost. Other states set a flat-rate dollar amount to restrict the maximum amount of I/D fees; the New Jersey Department of Transportation is one of the examples. Only one state Arizona had a limiting cap defined by time duration (+30 days) rather than dollar amount. Several states varied their cap amounts depending on the project. Some states even did not have any restrictions on the cap rates” (Shr, Chen 2004). Florida has utilized a variation of the incentive/disincentive provision that provides a variable I/D amount relative to the time of early or late completion. For example, a larger incentive is provided for a ten-day early completion than for a one-day early completion (AASHTO).

Incentives and disincentives work well for projects that are longer in duration and more expensive than the three projects I discuss in the thesis. For shorter projects of sixteen day duration and costing approximately three hundred thousand with limited scope of work the incentive disincentive does not work as well as expected. It is difficult to determine an appropriate I/D value and it is often too less to have a significant impact on the contractor. Using the state cap on the I/D value the incentive disincentive for the project I studied was too little to have significant impact on the project duration.

**Incentive/Disincentive cap rates for diff state agencies.** (Herbsman et. Al 1995; Shr 2004)

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29
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<td>Nevada</td>
<td>Varies</td>
</tr>
<tr>
<td>New Hampshire</td>
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</tr>
<tr>
<td>New Jersey</td>
<td>Dollars 100,000</td>
</tr>
<tr>
<td>New York</td>
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</tr>
<tr>
<td>North Carolina</td>
<td>Varies</td>
</tr>
<tr>
<td>North Dakota</td>
<td>5%</td>
</tr>
<tr>
<td>Ohio</td>
<td>5%</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>5%</td>
</tr>
<tr>
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<tr>
<td>Tennessee</td>
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</tr>
<tr>
<td>Utah</td>
<td>Dollar amount&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>Virginia</td>
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</tr>
<tr>
<td>Washington</td>
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</tr>
<tr>
<td>Wisconsin</td>
<td>Varies</td>
</tr>
<tr>
<td>Wyoming</td>
<td>6–8%</td>
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<sup>F</sup>Fixed.<sup>b</sup>Fixed except the A1B contracts.<sup>c</sup>Fixed or negotiated not available.
**Lane Rental:**

This is an innovative contracting technique that is used to minimize the impacts of the project on the traveling public. As the name suggests, it is a way of transferring the roadway user costs onto the contractor. The contractor thus has to rent the lane to do work on it. This rental scheme creates a monetary incentive for the contractor to be innovative and minimize the duration of lane closure. The contractor makes decisions that take the roadway user costs into consideration both during the bid and as the contract progresses. The contractor's bid consists of a combination of the cost to perform the work (A component) with the cost of the impact to the public (B component) to provide the lowest cost to the public. By providing a more aggressive scheduling package, a contractor may gain a competitive advantage by decreasing the overall impact on the traveling public, thereby reducing the amount for bid consideration (WSDOT).

The contract award for a lane rental contract is based on the formula:

\[
\text{The Bid Amount for Evaluation} = A + (B \times LRC)
\]

- **A** – Bidder’s total estimate for all contract bid items (expressed in dollars)
- **B** – Total number of days subject to lane closure, as defined previously, required to complete all contract work.
- **LRC** – Lane rental cost. These costs can be variable and applied to one or more lanes during a construction project.

This formula is used as a measurement for awarding purposes only, and is not used to determine payment to the contractor. The low bidder may not necessarily be the successful bidder. A bidder who proposes to minimize user impacts realizes the value of that benefit as part of their bid. They also run the greatest risk for damages (overrun of lane rental time credits) (WSDOT).
As discussed earlier this method also uses the road user cost that is difficult to correctly determine. Moreover, the concept of lane rental has not really caught on in this country.

Criteria for Selection (www.ic.usu.edu)

Lane Rental has been used for projects when one or more of the following conditions exist:

1) Traffic restrictions or lane closures result in high road user costs.
2) The use of alternate routes or off-site detours is impractical.
3) The traffic control plan allows the contractor flexibility in scheduling work to minimize the impact of lane closures.
4) The agency seeks contractor expertise to minimize the time that lanes are out of service.
5) The project is relatively free of third party conflicts, design uncertainties, or right-of-way issues that may impact the project schedule.
6) The benefit in terms of the reduced impact to the highway user is greater than the additional cost to minimize lane closures.

Lane Rental contracting has been used for the following types of projects:

- Major roadway, bridge, or interchange projects with high ADT and traffic restrictions of lane closures
- Projects or portions of projects involving temporary lane, ramp, or bridge closures
- Emergency repair work
**DOT Survey Responses (TRB:Ross;Donn E.Hancher)**

A survey of all fifty state DOTs and four Canadian DOTs was conducted to determine their experience with innovative contracting practices. Each agency was asked to identify innovative practices that have been tried, and to rate the benefit of using each innovation and the difficulty of its implementation. The paper does not mention the questions put forth to the state Dots. Secondly, authors used responses from both US and Canadian DOTs. The survey results are based on perceptions and attitudes that differ between the two countries. So, to club the surveys received from US and Canada and analyze them on the same platform is, in my opinion, incorrect. Out of all the DOTs, twenty-four responded and some these respondents were interviewed. The benefit perceived from each innovation was rated from 1.0 (low) to 5.0 (high). The difficulty of implementing the innovation was rated from 1.0 (easy) to 5.0 (very difficult). Several of the methods have been tried by most of the respondents. All of the methods tried have proven to be beneficial, but it is believed that most will be somewhat difficult to implement.

<table>
<thead>
<tr>
<th>Contract Innovation</th>
<th>% of Respondent Use</th>
<th>Benefit Received</th>
<th>Difficulty of Implementing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partnering</td>
<td>89.7</td>
<td>3.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Quality Control by Contractor</td>
<td>93.1</td>
<td>3.9</td>
<td>3.4</td>
</tr>
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</table>
Herbsman et.al (1995) studied four different types of innovative contracts; bidding on cost/time, Incentive/Disincentive (I/D), bidding on cost/time combined with incentive/disincentive and lane rental. The following were his conclusions and recommendations.

- Innovative methods have been successful in reducing time in almost every case by 20%-50% as compared to similar projects using conventional methods of construction.
- Cost/Time (A+B) bidding was found to be the most economical since time “reduction is achieved through competition rather than monetary payments to the contractor”.

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Warranties</td>
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<td>3.0</td>
</tr>
<tr>
<td>Lane Rental</td>
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<td>3.1</td>
<td>2.8</td>
</tr>
<tr>
<td>Design Build</td>
<td>48.3</td>
<td>3.0</td>
<td>3.3</td>
</tr>
<tr>
<td>A+B(Cost + Time)</td>
<td>69.0</td>
<td>3.5</td>
<td>2.4</td>
</tr>
<tr>
<td>A+B+C (Cost + Time +Quality)</td>
<td>3.4</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Constructability Review</td>
<td>65.5</td>
<td>3.9</td>
<td>2.9</td>
</tr>
<tr>
<td>Performance Specifications</td>
<td>52.0</td>
<td>3.3</td>
<td>3.0</td>
</tr>
</tbody>
</table>
• Incentive/Disincentive contract was determined to be more expensive and less effective than A+B method, which probably explains the reduction in the use of I/D contracts over the last few years.

• More data from case studies must be collected for further analysis of the lane rental method and (A+B plus I/D) which appear to be the most useful of the contracts.

• A standard procedure for calculating the value of time (DRUC) needs to be determined to correctly incorporate them into the final calculations.

• Research needed to establish an acceptable methodology for computing “reasonable” contract durations.

**Accelerated Construction:**

Transportation agencies are now committed to reducing construction time while maintaining high quality and building structures with longer life. Today’s focus has shifted from building new transportation facilities to resurfacing, rehabilitation and restoration (3Rs) of those already in existence. The highway system in the US is expansive and intricate, consisting of nearly four million miles of roads, street, tunnel, bridges and other structures (TRB). Roads and bridges in many parts of the country are being used passed their original design life, and by vehicles of shapes and sizes that were unanticipated at the time of their design and construction. The aging highway infrastructure requires more maintenance and rehabilitation and therefore, increased investment in infrastructure renewal. Moreover, high ADTs and road user costs, and unsafe road conditions due to construction further demonstrate a need for accelerated or fast track construction. These practices aim to reduce the time during which work zones are in place.
and extend the period between rehabilitation cycles by improving the durability and prolonging the effective life of pavement restoration.

Jaraiedi et.al (1995) set guidelines for accelerated construction projects. “To ensure the successful completion of the I/D project, it is important for the contracting agency to do everything possible to eliminate delays and disruptions in the construction. Therefore, the contracting agency needs to anticipate potential trouble spots and develop methods for dealing with them.” The following points need to be taken into account while preparing and executing I/D contracts.

- To avoid expensive field changes once the projects starts, special attention must be given to project development, and predesign field reviews as the latter may be different from those indicated on old construction plans. This point about extensive field reviews before the construction begins is very pertinent and relevant. In the bridge in Guernsey County the field reviews were not in place when the construction began and a surveyor had to be brought in mid way through the construction to determine the centerline. This was counter productive and delayed the construction.

- The contract must explicitly specify the procedures that need to be followed in case there is any change in the scope of the work, the I/D completion date needs to be extended, and under what circumstances the contractor is responsible for delay.

- The contract must clearly define when the I/D time will begin and end, as it may be different from the start and completion date of the rest of the project. It is important that the contract defines in detail what is expected of the contractor to earn the incentive payment. This would include a detailed list items that may be completed after the I/D completion date, such as shoulder and cleanup.
• Every party involved in the construction process should participate in pre-construction meeting to discuss and uncover any unusual features of the project. This was followed for all the projects under the Strategic Initiative every party involved was satisfied and noted that it contributed in a positive manner to the outcome of the project.

• A written agreement needs to be signed between the contracting agency and the utility company prior to the contract award to mention what work will be done when and to avoid conflict with the utility company once the works begins.

• Right of way issues also need to be addressed before construction to avoid unnecessary delays.

Every suggestion made on accelerated construction is pertinent and will contribute greatly if followed and implemented for future projects.
ACCELERATED PRECAST BRIDGE CONSTRUCTION IN OHIO

Abstract:

The Ohio Department of Transportation (ODOT) created Strategic Initiative #9 to “Build Bridges Smarter, Faster and Better”. One project undertaken by ODOT was to use a precast, post-tensioned slab bridge in place of a cast-in-place slab. To accommodate school schedules and a festival, the bridge was to be completed in 16 days. However, the bridge was actually completed in 19 days. Delays were due to weather, equipment problems and confusion over plans and specifications. Contributing to the success of the project is the effective partnering between ODOT and the contractor, as well as a high level of upfront planning. However it is necessary to address problems such as the lack of contingency plans and some unexpected issues that were overlooked in the planning phase.

Introduction

Since 1995, the Ohio Department of Transportation's (ODOT) customer focus has led the Department to improve its maintenance-of-traffic (MOT) practices. ODOT’s MOT concerns are driven by the desire to respond to complaints about detours and road closures. Ohio has a large transportation network and as such the magnitude of delay caused by construction is greater in Ohio than in many states. Ohio has the 10th largest highway network, the fifth highest volume of traffic, the fourth largest interstate network, the fourth largest amount of freight shipments and the second largest inventory of bridges in the US.
As the department’s MOT policy has been established, the role of bridge construction stands out as a limitation. Generally, the speed of bridge construction and repair is the limiting factor in the completion date of a highway project and therefore the length of time the traffic is affected is directly impacted by the speed of bridge construction. ODOT created Strategic Initiative #9 - Building Bridges Faster, Better, and Smarter to address this issue. The initial objective of this initiative was to identify structural design concepts which would be used in pilot projects such as:

1) Stay In Place (SIP) Forms
2) Full depth precast bridge decks
3) Box beams with transverse post-tensioning and the top flange ground to profile.
4) Box beams with transverse post-tensioning and a composite cast-in-place wearing surface
5) Single span steel beams made continuous for live load.

None of these concepts is new, but they have not been previously used in Ohio. This paper describes the result of one pilot project, a longitudinally and transversely post-tensioned, precast box girder bridge with the top flange ground to profile.

The Bridge
The bridge is located in Quaker City, Ohio, a rural town located approximately fifty miles east of Columbus (Figure 1). This structure is over the Leatherwood Creek on State Route 513, which is the only north-south thoroughfare through the town. Closure of this bridge would have resulted in a 20 mile detour for automobiles and a 40 mile detour for trucks and buses. Since this route is used for school buses, local officials had concerns about the long detour and also about
possible safety issues that may arise if the bridge was reconstructed with part-width construction (i.e. 1/2 of the bridge is left in service while the other half is reconstructed - this reduces it to a one-lane, signal controlled bridge).

To answer these concerns, ODOT decided to use a 16 day window in late June to reconstruct the bridge. This window period corresponded to the end of the regular school year and the beginning of summer school classes. Quaker City also hosts the annual Ohio Hills Folk Festival which was held from July 10th through the 13th in 2003, so it was imperative that the bridge be completed and operative by this time.

At the time construction started, the existing structure was a two span, continuous, reinforced concrete slab bridge with reinforced concrete substructure built in 1952. Given the site and span, a new slab bridge seemed to be the logical replacement, but a conventional slab could not be built within the time constraints. The new bridge was a two span structure consisting of two-way post-tensioned precast concrete modular slabs on an existing reinforced concrete substructure (Figures 2-7). Longitudinal post-tensioning was used to create continuity over the support and to enhance the positive moment resistance. Lateral post-tensioning was used to compress the joints between the modular slabs to prevent cracking of the joints. The approach slabs were also post tensioned. Details of the bridge are shown in Figures 1-5. The superstructure was designed using the AASHTO Standard Specifications\textsuperscript{1} HS-25 truck and the alternate military load specifications.
Pre Construction Meeting

ODOT normally holds preconstruction meetings on all projects. For this project, the pre-construction meeting took on added importance as both ODOT and the contractor viewed it as a way to discuss potential problems before construction started.

Bridge construction was a fast tracked process that had to be completed in 16 days with work being scheduled between June 16\textsuperscript{th} and June 30\textsuperscript{th}, 2003. The proposed work included the following:

1. removal of portions of existing concrete deck, sidewalk, railing and substructure units
2. construction of new portions of a cast-in-place abutment and wingwall;
3. setting of the precast bridge units, precast approach slab and precast railing;
4. grouting of the beam seat areas and the areas below the approach seats;
5. grouting the shear keys;
6. lateral and longitudinal post-tensioning;
7. grouting post-tensioning tendon ducts;
8. grinding and grooving the final riding surface;
9. placement of the sidewalk concrete
10. epoxy coating the sides of the fascia girders and general clean-up.

To assure the work was completed in a timely manner, ODOT held the pre-construction meeting six months before construction was to begin. The meeting was attended by representatives from ODOT, the general contractor, the post tensioning subcontractor, the precast fabricator and the design engineering firm. Among the issues discussed were:
1. The contractor intended to employ two work shifts of eight hours each and work 7 days each week. Quaker City has a noise ordinance which would preclude this. Since this was to be a short duration project, ODOT responded by approaching local officials and neighbors affected by the noise and securing permission to work the needed hours. One unusual condition was noted: because a funeral home was located next to the bridge, therefore it would be necessary to curtail noise if there was a funeral being conducted. Since this was an unpredictable and unlikely event (given the size of the town) the decision was made to use the proposed schedule and adjust it as needed.

2. According to the plans, the contractor was to saw cut existing slab from the abutments. He sought permission to do this before the bridge was closed to traffic in order to be slightly ahead of the work schedule. ODOT allowed this after the contractor had an engineer investigate the issues related to structural stability.

3. The plans required the contractor to conduct a mock up test fit on the modular slab units before installation. This was to ensure the correct alignment of the ducts for the post-tensioning strands. The mock up test would also help in checking the basic fit of the beams as any problems which might occur once the installation began at the site would be difficult to resolve within the restricted time frame. The mock up was to occur at the precast yard.

4. It was decided by the parties present at the meeting that weather days would be allowed as the contractor cannot control the weather. ODOT rules permit that a weather day is allowed only if less than two hours of work is performed on that day.
Mock Up Tests

A section in the special provisions in the contract provided for a full mock up test for the bridge assembly in the yard before the final assembly on the site. This requirement was included to check for proper fit-up and alignment, and to verify that every beam unit was constructed in compliance with all the plan requirements. The contractor was to use ‘blocking’ to stimulate the beam seats elevations at the abutments and pier.

The slab components were all assembled according to the provisions of the contract. After inspecting the mock up test, the inspectors agreed that the fit was good. Post-tensioning cables were installed in all the decks (but not tensioned) to verify duct alignment. Material tests showed that all the materials met specifications.

During both the pre-construction meeting and the mock up assembly, the precaster expressed a concern about the post-tensioning. The standard procedure is as follows: to post-tension one or two strands, measuring force and elongation. This data is then sent to the ODOT engineers for verification and approval. This can sometimes take a few days. In this case, such a delay would be unacceptable. ODOT agreed to have people on site to verify the post-tensioning.

Construction

The construction work started as scheduled on June 16th and ended on July 3rd. This was 3 days behind the original plan of completing work by June 30th. Some of the significant delays were:

1. Work Shifts: Although the contractor had intended to work two 8 hours shifts per day, the contractor actually worked a single shift each day. The shift length varied from day-to-day but averaged about 12 hours each day. This has the effect of losing 4
hours per day of work and increasing labor costs as the contractor must pay time and a half for the extra hours. The contractor cited two reasons for this. The first was that there was dead time in the day (e.g. waiting for grout to cure) and thus there was no justification for the additional shift as there was not always 16 hours of work which could be done each day. It was better to employ a single shift for however many hours were needed each day. Secondly, the overlap time between shifts would be long since the supervisors would have to explain, in detail, every aspect of the work to the incoming supervisor who in turn would then have to repeat the process with the workers. This is a time-consuming and tedious process. For each shift there is always some start-up and finish-up time (e.g. getting out or putting away personal tools). The contractor thus determined that a single shift would be most efficient.

2. Weather: Some of the delay was due to rain, which occurred on 3 different days. This pointed out a problem with the current ODOT rules which allow a weather day only if the contractor works less than 2 hours (This presents some incentive to the contractor not to work if he cannot work the entire day). Since the contractor was working extended shifts, the number of hours lost was potentially significant. In a fast track situation, it is to ODOT’s advantage to have the contractor work as many days as possible, even if it is only partial days. Fortunately, ODOT used a partnering system. When a situation like this arose, the contractor and ODOT representatives met to find a mutually beneficial solution. As a result, ODOT granted some relief for weather even if the contractor worked more than 2 hours in a day.

3. Equipment Problems: Some of the delay was due to equipment problems. On the first two days there were delays due to malfunctions of the track hoe used to break up
the old concrete. On the tenth day, there were problems with a crane. Clearly, these delays could have been avoided by ensuring that reserve equipment was available. Two essential parts of the fast track process are cost-benefit analysis for reserve equipment and the probability that reserve equipment will be needed.

4. Choice of equipment: The existing deck was removed by using a rock drill, which was a tedious process. It was suggested by the site supervisor that saw cutting the deck and then removing it with a crane might have saved time. In addition of this benefit the above method reduces vibrations and thereby does not damage the remaining substructure units.

5. Shipment Delays: On day 5, the wrong deck units were brought to site. This caused a delay until the correct units were shipped. This would not have been much of a factor on a normal job, but it was important on a fast track job. This shows the need to verify all shipments in these cases.

6. Field Verification Problems: In one case the plans of the bridge did not mention in detail the exact amount of concrete which needed to be removed from the wing walls because the contractor neglected to mark the centerline of the existing bridge before removal. Because of the ensuing confusion about the placement of the new structure, a surveyor was called upon to determine the centerline. It is always important to verify site conditions before construction, but for a fast-track job it is even more critical.

7. Beam Placement: Another significant problem occurred during the placement of the beams. The mock up test was carried out on flat ground, but the site conditions were very different. The abutments were sloped and this was not accounted for in the
mock-up tests which were carried out on flat ground. Significant adjustments were
needed to achieve the correct alignment of the beams on site. This alignment
problem also occurred with the PT ducts which were aligned perfectly during the
mock ups, but on site it took extra effort and time to get them in line.

8. Grout: The type of grout needed for the shear keys (between the girders) was
specified in the contract as a non-shrink grout with a minimum strength of 6000 psi
prior to transverse post tensioning. Exposed concrete surfaces at blockouts and
recesses had to be treated with a bonding agent prior to filling. However, it appears
that parts of these provisions were overlooked by the contractor in the initial bid
phase. The contractor then had to work quickly to find a suitable grout. The grout
initially chosen by the contractor was not on ODOT’s list of accepted grouts and so it
was rejected. A second grout was chosen from the approved list. The grout took
almost twenty hours longer to set as compared to the one chosen by the contractor
(this contributed to the contractor’s decision to use one shift). The grouting company
was not familiar with the type of grout it used so had difficulty in working effectively
with the grout. The grout did not come up to the required strength, although there
were questions about whether the grout testing was done correctly. Normally, the
grout between the beams is not an issue. The inspector verifies that the grout is
mixed to the manufacturer’s specifications and the grout is then poured into the
keyway. On a typical ODOT design, the grout is covered by waterproofing and
asphalt or a cast-in-place composite deck. Since the grout is covered, no additional
testing is done. For this bridge, the grout joints are exposed so a tighter quality
control was needed. Testing procedures for the grout were available, but since the
grout is usually not tested, no one thought to bring the testing equipment. Make-shift cylinders made of plastic pipe were used for specimens. In addition to the testing problems, the grout shrunk after curing and the cracks in the joints had to be sealed with High Molecular Weight Methacrylate (HMWM).

9. The bridge was designed to use the top surface of the beams as the final riding surface. After placement, post-tensioning and grouting, the tops of the beams would be ground to profile and grooved. However, the lifting lugs and post-tensioning grout tubes protruded from the top flanges of the beams. No one thought to leave ‘dish-outs’ around these protruding elements so that the contractor could cut them back below the final riding surface. As a result, the contractor had to create these ‘dish-outs’ by jack-hammering them into the top flange. The protruding elements were cut back and the ‘dish-outs’ were covered with grout.

An exception to the A+B contract was made towards the final stages of construction. The contractor was permitted to complete work such as site clean-up, sealing the sides of the beams, etc., after the bridge was opened. The final bridge is shown in Figure 8.

**Post Construction**

The post construction meeting was held after the completion of the construction to discuss the construction and suggest improvements. Attendees included by representatives of the ODOT, the prime contractor, various sub-contractors, the design engineer and the research agencies.

The first issue raised concerns grouting work. As stated previously the contractor originally wanted to use a quick setting grout which did not appear on the list of ODOT’s
approved list. Despite much deliberation ODOT did not allow the new grout and insisted that the contractor to use a grout from the approved list. All of these grouts took more than 24 hours to set. In fast track construction the contractor may need a greater voice in choosing the construction materials as long as the quality is not compromised. The Contractor suggested that ODOT should either add more materials to the approved list or completely do away with it; perhaps replacing it with a performance based specification. Giving the contractor greater flexibility may help in cutting down the construction time.

Also discussed at this meeting was the partnering relationship that developed between the ODOT and the contractor that encouraged efficiency and amicably. The role of the project manager also came up. It was observed that it is usually difficult to contact or seek immediate advice/suggestions from the ODOT engineer or the design engineer. In this project the manager assumed more of a proactive role and provided the necessary clarifications whenever they were sought.

The contractor also mentioned that in a project of short duration like this one, motivating the entire team is a difficult. Given the time constraints tasks cannot be spaced out and must be performed one after the other. Also there is no luxury of pausing and thinking about the problems. Problems adversely affect the morale of the team.

Observations by Research Team

In the end, the Quaker City Bridge Project was a success. The bridge was completed in 19 days rather than 16 days, but it was still completed within a reasonable enough time that projects objectives, having the bridge open for school bus and festival traffic were accomplished. The research team made several observations:
1) The incentive on the project was $5000/day, $25000 maximum. The penalty was $5000/day. State law limits these values. The research team noted that these are not large incentives or penalties. While these incentive/disincentives will work to speed up construction, they will do so only in a limited way as the dollar values are not that high. In another SI-9 project (PIC-22), the incentives and penalties were much higher and the contractor responded by bringing in his best crews, bringing in extra crews, looking for innovative ways to speed up construction, etc.
2) Construction was slowed by equipment break-down. The research team wondered why spare equipment was not available.
3) Grout selection and quality control of the grouting process are major issues. These same issues came up on several SI-9 projects. Unlike other ODOT projects where the grout work is usually covered with a layer of concrete or asphalt, the grout in this case remained exposed. It seemed that the need for better grout QA/QC was missed. Issues regarding selection that were discussed in the previous section indicate a need to have better QA/QC for the grouting process.
4) The fact that the bridge was prefabricated greatly contributed to the speed of construction and post-tensioning that made the design efficient. Post-tensioning was an issue only because of the limited number of both contractors who do such work and suppliers of post-tensioning materials. The precaster noted that he got no response from some post-tensioning material suppliers when he asked for bids. There is a concern that, in the future, the ability to construct post-tensioned bridges quickly may be limited by the availability of contractors.
5) In a project of this nature the margin of error is very small. There are many ways in which the project could get off schedule such as faulty or broken equipment, inclement weather, shipping delays/problems and material/labor availability could all affect the schedule. In order to minimize these factors the contracting agency could ask for a contingency plan from the contractor even before the project begins. This potentially offers a certain degree of assurance that, if the project is delayed for unavoidable reasons the contractor will get it back on schedule.

Conclusions

The Quaker City Bridge was the first of the series of six bridges that would be built in Ohio using innovative techniques, methods and materials to reduce the time of construction. Fast tracking hadn’t been used extensively in Ohio before so this was a first time effort for both the contractor and the contracting agency. The project was a success even though it was completed three days late. In the end, ODOT agreed that some of the delays were beyond the contractors’ control (such as rain) and the contractor received one day’s incentive. Some conclusions drawn from this work were:

1. Partnering is essential. The contractor and contracting agency formed a cordial relationship of partnering that ensures an atmosphere conducive to quality performance. Just as the contractor was motivated to do the job well and on time, the contracting agency promptly assisted when needed. The role assumed by the project manager in this project was proactive. There were times when the engineer could not immediately be reached. The manager had the authority to make some of the decisions which otherwise would have to wait for the engineer. This kept the work
progressing and delays due to the inability to communicate with the engineer were avoided.

2. The design engineer must be aware of local contractor capabilities. The design used was a first in the state of Ohio. Given that post tensioning has not been used extensively before and there are currently only two post tensioning companies in the state each specializing in different materials for post tensioning like rods or strands. If a bridge is to be post tensioned using a particular material there will be complete dependence on one company. This over dependence may lead to complacency on the part of the supplier and any problem faced during post tensioning could adversely affect the schedule. And, strictly adhering to the schedule is of paramount importance in a fast tracked project. Thus, when designing it might be helpful to keep in mind the skill of the contractors and the sub contractors and the availability of the materials needed for the construction.

3. Use of unusual specifications must be clearly flagged. There were significant issues with the selection of and the QA/QC for the shear key grout. Most of these issues revolved around the fact that performance of the keyway grout for this project had to be much better than that for a normal adjacent box beam bridge. When there are unusual material requirements, the design engineer needs to be sure that the state agency and the contractor(s) are aware of these requirements. Simply adding language to the project specifications is insufficient as this may be overlooked. Some type of a letter specifically outlining these issues is needed.

4. Lowered morale can be a problem. Since there are difficulties/problems being faced throughout the construction process the morale of the construction team may
sag. It is necessary that an effective channel of communication and problem solving
mechanism be in place so that the morale of the construction team remains
consistently high.

5. Incentives may not always be sufficient. The contractor bid 14% below the state
estimate at $379,000 to win the A+B contract for this construction. The incentive
offered was $5000 per day up to a maximum of $25,000. At the post construction
meeting the contractor said that this was a sufficient incentive. However, there is a
question as to how much a contractor would do to earn a $25000 incentive. To earn
any incentive, the contractor might have to employ an additional shift of workers,
work with additional equipment or keep equipment on stand by so as to offset delays
due to equipment malfunction. The incentives may not be large enough to make
these options cost-effective.

6. Agency policies may have to be changed to facilitate fast track construction. For
example, the ODOT rain delay policy may encourage a contractor not to work on a
given day rather than work a partial day.

7. Contingency plans are needed. It would be useful for both the state agency and
the contractor to explore “what if” scenarios, e.g. what if the crane breaks down, what
if a certain material isn’t available, etc. By anticipating problems, the job schedule
can be maintained.
Chapter 4

COMPARISON OF THE CONSTRUCTION OF

TWO SIMILAR BRIDGES

Abstract:

The two bridges discussed in this chapter were built as part of the Ohio Department of Transportation’s accelerated construction initiative. The bridges, the first in Clinton County and the second one in Montgomery were built by the same contractor using similar methods but one was a success and the other not. The first bridge had problems with setting the girders; the grout seeped into the post tensioning ducts and interfered with the post tensioning while many of these problems were successfully ironed out during the construction of the second bridge in Montgomery. This chapter details the difference in construction and planning that was adopted to ensure the successful construction of the second bridge. This case study is an example of the learning curve which any such innovative “first time” projects experience.

Introduction:

The Ohio Department of Transportation implemented Strategic Initiative #9, “Build Bridges Faster, Smarter, Better,” to address the problem of bridge construction being the bottleneck in highway construction projects. One solution to this problem is the use of precast / prestressed elements with integral wearing surfaces (16). Ohio has used adjacent box girder structures for many years. Usually, the structure is a non-composite box structure (Figure 1), where the adjacent boxes are covered with a waterproofing membrane and then a layer of asphalt. Construction of the asphalt-wearing surface takes additional time. The asphalt also
tends to trap salt laden water against the top of the concrete boxes, leading to rapid deterioration in places where the membrane has failed or is damaged. The need for the asphalt surface could be eliminated by increasing the thickness of the top flange of the box girder and using this increased thickness as the wearing course.

Another problem with adjacent box girder bridges is leakage of the joints between the members. These joints, called shear keys, are meant to transfer shear forces between adjacent members. The origins of the shear key are not clear. The current design comes from early, two-stemmed precast members. The members are channel shaped with the opening facing down. They were connected by forming indentations in the side of each member. When placed side-by-side, the indentation formed a pocket which could be filled with grout and would lock the girders together. The key was at the top of the girder so it was adjacent to the flange. Later, the channel shape was made into a box by adding a bottom flange. This improved both the flexural strength and the torsional rigidity of the member. The shear key was never moved.

The shear keys tend to crack and leak. Research has shown that cracking is caused by perpendicular tensile forces which occur due to temperature and truck loading. The performance of the key can be improved by moving the indentation to the mid-height of the girder and using full-depth shear keys.

The use of lateral post-tensioning can further improve shear key performance by pre-compressing the grout in the key joint. The AASHTO LRFD Specifications require the use of lateral post-tension in order to use the most favorable distribution factor. The LRFD Specifications require that the post-tensioning provide a stress of 250 psi, but is not clear if the means 250 psi along the entire side of the girder or just in the joint.
Several states use lateral post-tensioning for adjacent box girder bridges. However, Ohio has never used this design. As part of Strategic Initiative 9, Ohio DOT decide to build two, laterally post-tensioned box girder bridges. One would use an integral wearing surface and the other would use a cast-in-place composite wearing surface.

**THE BRIDGES:**

**CLINTON-730**

CLI 730 is located on state route 730 over the Lytle Creek in the Town of Wilmington, just west of I-71, halfway between Columbus and Cincinnati. The original structure, built in 1953, was a continuous concrete slab with capped pile abutments and piers and a ¾” monolithic concrete wearing surface. Current year (2000) ADT on the bridge is 6654 while the design year (2020) ADT is 9744. The replacement structure was single span, precast, prestressed concrete non composite box beam on reinforced concrete integral abutments. The beams were ninety-four feet long with an integral wearing surface and were designed for HS-20 or the alternative military loading.

The innovations implemented in this project are:

- Box beams with an integral deck precast into the beam, with variable thickness top flange/deck to account for camber and a sag vertical curve;
- Box beams are transversely post tensioned to improve key way joint performance.
- Final profile grade is achieved with surface grinding of the precast integral deck.

Six companies bid for this job and the contract was awarded in May 2003 with completion scheduled for October 2003. The construction was to be completed in two phases
with the bridge kept in operation as a signalized single lane. This project also included all grading and drainage to construct the replacement structure.

**MONTGOMERY- 70:**

MOT 70 was built over I-70 just north of Dayton, OH. The original bridge, built in 1956, was a continuous steel beam with reinforced concrete deck and substructure. In 2002, the bridge was struck by a truck and so seriously damaged that removal was required. Present (2004) ADT on the bridge is 5300 and is expected to rise to 5800 in 2024. The new structure is a two-span, prestressed concrete box girder bridge with a cast-in-place composite deck. Semi integral abutments and reinforced ‘T’ type piers were used. Span lengths are 73 feet and 110 feet. The bridge was designed as continuous for live load with an HS25 loading. The innovative feature of this bridge is the use of lateral post-tensioning.

**Comparison of the Bridges**

Both bridges used transversely post-tensioned, prestressed box girders. However, this was the only common feature. The differences between the two bridges were:

1) CLI 730 was a single span; MOT-70 was a two-span, continuous for live load structure.

2) CLI-730 had an integral wearing surface, which would be ground to profile; MOT-70 used a cast-in-place, composite surface.

3) CLI-730 was designed to use post-tensioning bars for the transverse post-tensioning; MOT-70 used strands.
4) CLI-730 was constructed in two phases; MOT-70 was not.

One important similarity between the two projects was that the same contractor won the bids for both jobs.

**CLI-730:**

**Preconstruction:**

The preconstruction meeting was held almost a month before the start of construction and was attended by representatives from ODOT and the contractor. The contractor set a tentative start date of June 12th 2003 with a final completion date of October 3rd 2003. An interim date of completion was set for September 3rd.

An informal partnering agreement developed between the contractor and the contracting agency. It was decided at the pre-construction meeting that the administration and dispute resolution process would be based on the partnering approach. After the dispute resolution and the claims processes were discussed, the accepted procedure was agreed upon. They decided that grinding the top of the beams to profile would be done once all the beams are put in place rather than doing it in phases. The post tensioning company opined that the standard procedure for grouting would not leave sufficient space for the post tensioning in phase two, thus the design was slightly altered to loosen the tensioning.

One problem which came to light in the preconstruction meeting was the size of the beams. The original intent of the design employed the normal, noncomposite girder section and add a ½” wearing surface. This would have made the top flange 6” thick. Instead, the design engineer elected to use the top flange thickness of the standard composite section. The composite section has a 3.5” top flange and a 4” cast-in-place slab, making the minimum top flange thickness 7.5”. Because the bridge was at the bottom of a vertical sag curve, the flanges
at the ends of the girder were thicker. This was heavy enough to make the girders permit loads. It was noted that two cranes would be required for placement of beams. The decision was made to close to the road to traffic during this operation.

A system for regular review of the estimates and the progress of work was set in place on the tenth and the twenty-fifth of each month. Since the design was new and unfamiliar, the contractor had some uncertainties. The contractor found that it was helpful to ask questions and seek addendums.

Fabrication and Construction:

Due to the unusual nature of this bridge, there was a higher level of communication between ODOT, the contractor and fabricator than normal. The role of experience was apparent in the early stages of fabrication. ODOT had constructed another integral wearing surface, laterally post tensioned bridge in Guernsey County. On the Guernsey County bridge, no one had accounted for lifting devices and grout ducts left protruding from the wearing surface. On this previous job, the contractor had to chip around the protruding elements so that they could be cut below the surface and grouted over. For the Clinton bridge, the fabricator made dish-outs around protruding elements.

The plans for both the Guernsey and Clinton bridges required that pre-construction mock-up assemblies be made in the precasting yard. This was to assure alignment of the post-tensioning ducts. However, for the Guernsey bridge, the mock-up was done on regular dunnage and did not account for the slope and crown in the actual abutments. Although the beams for the Guernsey bridge appear to align correctly in the yard, there were alignment problems during
field assembly. To counter this, the mock-up for the Clinton bridge was to be done on mock abutments, which had the correct slope and crown.

Because the construction was phased, the contractor was concerned about differential camber at the construction joint. To counter this, the fabricator and contractor attempted to control the camber of the phase II beams. After the mock-up was approved, the phase I beams were shipped to site, but the phase II beams were left in place on the mock-up abutments. The contractor installed the phase I beams, and then measured the camber at weekly intervals – always on the same day of the week at the same time. This camber was transmitted to the fabricator who then attempted to adjust the camber of the phase II beams with addition or removal of dead weight.

The use of the integral wearing surface created additional work for the fabricator. Due to the vertical sag curve, the top of the boxes had to be curved. The fabricator had to extend the forms by welding on a metal plate.

The first problem was found during the mock-up. The post-tensioning contractor had supplied thin walled PVC ducts for the bars, which is common. However, during fabrication, the ducts floated due to the hydraulic pressure of the wet concrete; in the mock-up phase, this did not appear to affect the placement of bars. As a result, although the ends of the ducts were in the proper places, there was a noticeable curve to the ducts in each girder.

The first construction problem occurred during placement of the beams. It was necessary for the contractor to align the post-tension ducts during placement that required two cranes to place—a difficult task when using heavy beams. The situation was further complicated because the bridge uses integral abutments, requiring that the reinforcing bar protruding from the abutments and the ends of the girders be meshed during placement. Interference between the
bars made it difficult to make the small adjustments in the beam position needed to align the PT ducts.

The purpose of lateral post-tensioning is to compress the keyway and prevent cracking. This necessitates that the keys are grouted before the post-tensioning is done. Since the bars must pass through the shear keys, it is necessary for the ducts to be sealed at the shear key. ODOT recommended the use of large, donut gaskets used by Michigan DOT. The contractor elected to use a thinner gasketing material. ODOT personnel did not require the thicker gaskets, as this was considered a “means and methods” issue rather than a material specification issue.

During placement, the beams had slight lateral deflections (sweep). This sweep was not out of tolerance, but over a 70-foot long beam, the gap at certain places between the beams was as much as ½” wider than expected. The contractor has to add additional gasketing material at these places. There was also a problem with getting the beams to “snug up.” The contractor suggested that a small post-tensioning force be put on the structure prior to grouting to pull the girders together, but ODOT did not allow this.

Additional problems occurred during the shear key grouting operation. The bridge used full depth shear keys which were created by using the normal shear key design and leaving a 1 inch gap at the bottom. The contractor filled this gap with foam backer rod glued to the side of the beams with construction adhesive. This proved to be inadequate and there were numerous blow-outs during the grouting operation. A matter of more importance, however, was that the PT ducts had not been properly sealed and shear key grout leaked into the PT ducts. The contractor had been required to put the PT bars into the ducts before grouting the shear keys to verify alignment. Unfortunately, the bars were left in place and some of the bars were grouted into place prior to being post-tensioned. When the contractor attempted to post-tension the bars,
it was discovered that some of the bars did not have the required elongation at the required
tension. The contractor decided to free the stuck bars by loosening the dead head anchorage and
applying the PT force, but worked only in isolated cases. The final post-tensioning results are
summarized in Table 1.

**Table 1 - Phase I Post tensioning summary**

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<tr>
<th>LOCATION</th>
<th>TOP TENDON</th>
<th>MIDDLE TENDON</th>
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Most of the difficulties on Phase II were a direct result of the problems encountered on
Phase I. The plans called for the post-tensioning bars to be coupled at the construction joint
using a standard mechanical coupler. Because many of the Phase I PT bars had inadvertently
been grouted in place prior to being post-tensioned, their final position could not be readjusted to
assure alignment with the Phase II couplers. The alignment of the phase II bars was also
uncertain. The engineer had provided a 2 inch diameter duct for the 1 3/8 inch diameter bars.
Differential camber caused some minor misalignment of the adjacent members’ ducts. The ducts had floated when the beams were cast, so the ducts were not perfectly straight. While these factors did not prevent the bars from being placed through the beams, it greatly limited the ability of the contractor to align the phase II bars with the phase I bars. ODOT requested that the ducts on the phase II beam be cored to a larger size to allow adjustment of the PT bar positions, however, when this was tried it was found to be impractical. ODOT decided to simply leave things as they were and see how many bars could be coupled. After assembly of phase II, it was found that 24/27 bars could be successfully coupled. The three bars which could not be coupled to phase I were anchored at the construction joint. The results of the post-tensioning are shown in Table 2.

**Table 2 - Phase II Post Tensioning Summary**

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In the end, the bridge did not perform as expected. Cracks occurred in the shear keys, especially in phase I. As a result, some of the joints leaked when it rained. This bridge was constructed by ODOT, but was to be maintained by Clinton County. ODOT did not want to give the county a bridge with a maintenance problem, so a waterproofing membrane and an asphalt wearing surface were added.

**MOT-70**

**Construction and Mock up:**

Construction of the Montgomery County bridge began while the Clinton County bridge was being constructed. The same general contractor did both jobs, but the precasters on each job were different.

**Improvements and other issues:**

1. **Metal sleeves:** PVC sleeves were used in the beams for CLI-730. These sleeves moved while setting the beams thereby making the alignment of the sleeves a difficult task to achieve. For MOT-70 the precasters used temporary metal sleeves. The metal sleeves did not move while setting nor did they buckle and formed an unobstructed straight channel for the strands. Alignment of the sleeves was therefore not a problem and it was easy to slip the strands through them. They were removed once the strands were in position.

2. **Abutment slope replicated:** In another bridge constructed under the pilot project, the mock up test was conducted on flat ground while the abutments were sloped. As a result, the placement of the beams and their subsequent alignment was tedious and it caused significant
delay to the tight schedule. The mock up test for MOT-70 were conducted with the slopes of the abutments being replicated in the yard. Use of the abutment gradient (which can never be exactly replicated in the yard) meant that the contractors were more prepared for the placement of the beams and their alignment. The twenty beams for the double-span bridge were put in place in five nights by working three to four hours every night.

3. **Sealing P/T Ducts:** It was imperative that problems from CLI-730 were overcome on this project, so the contractor sealed the P/T ducts with much caution. ODOT personal also assumed a more supervisory role to ensure that the doughnuts were sealed carefully and that no gaps were left when the beams were being positioned. In the previous project, ODOT had maintained a “wait and watch” policy and were not forthcoming with suggestions and guidance for the contractor. This however changed at the MOT project where the agency took a more proactive role and worked together with the contractor in making it a success. The “belly” on the beams (the slight bulge at the center of the beams) made sealing the gaps between the doughnuts of adjacent beams difficult. “Come alongs” were used to bring the beams closer for a better fit. Finally a slight pre tensioning of the lateral post tensioning tendons offered a better seal to the p/t ducts.

4. **P/T Strands:** Strands were used for post tensioning instead of the bars that were used at CLI-730, which proved easier to push through the sleeves than the bars. The metal sleeves also helped provide a clear straight channel to push the strands through. Moreover, since the strands were lighter than the bars and could be bent slightly, it was always going to be easier to work with them rather than the much heavier and thicker bars.
5. **Camber:** The pre caster for MOT-70 made two beams together and all the beams on the same bed in the yard unlike for CLI-730. As a result, there were fewer problems with camber faced on this project.

6. **Sweep:** Beams were designed with lesser sweep (sideways deflection) which helped with the sealing of the post tensioning ducts.

7. **Transportation:** The beams to be transported were very large and special trucks were needed to transport them from the yard to the site. Such trucks are not easily available and the schedule is heavily dependent on the availability of these trucks. Ideally the contractor would like the beams to be all brought together rather than repeat the entire process to bring five beams everyday.

8. **Permits:** Permits for the trucks also became a cause of concern during the transportation process. The permits were not good for the evening and most of the transportation had to be completed in the day. One day a truck broke down along the way to the site, but the local police disallowed a request to transfer the beam on to another truck and bring it to the site. The work for the evening was lost which becomes quite crucial in projects of such nature. State rules did not allow work on weekends over a busy interstate like I-70 but special permission was sought and later granted to make up for the lost work.

**Post Construction:**

**CLI-730:**

A post construction meeting was held after the completion of the construction of CLI-730. It was attended by representatives from ODOT, the contractor and the sub contractors. The contractors mentioned that the lack of data made it difficult to come up with a more accurate
estimate of the project. Moreover, the lack of familiarity with this type of design created some uncertainty. The contractor opined that holding a pre bid meeting would be helpful and especially beneficial for the pre caster as certain questions could be answered. A pre bid meeting gives an opportunity to the parties involved to raise and discuss several issues before the construction begins. It was noted that though there were extensive notes on camber, but perfecting the camber was a difficult task and it may have increased the budget substantially. Of the two post tensioning companies operational in Ohio, only one bid for this project. The lack of experience on their part was a definite deterrent to bidding and such a scenario often results in too much dependence on a subcontractor. Centerline of the structure was discussed and suggestions were made on dry packing it and improving the connections. It was suggested that the bottom of the shear keys be sealed so as to prevent the grout from oozing out. Risk factors for a project in which contractor and sub contractors have insufficient experience is high and the incentive offered did not match the risk nor encourage the timely completion of the project. Lead times for fast tracked projects are typically lower. The contractor pointed out that there was very little time for communication with the subs and higher level of planning needed to be achieved for successful completion of the project. For example, shop drawings which had to be approved by ODOT took longer than expected and this delayed the delivery of the beams. Plastic tubes were used for the duct for post tensioning which moved as the beams were being set. As a preemptive move, metal sleeves were used instead at MOT-70 and the results were significantly better. It was asked if the use of bars was determined by any design need and noted that the strands are definitely easier to handle. Phasing the construction and the post tensioning were said to be deciding factors. The pre approved grout used for the shear keys was not waterproof and the approved waterproofing cracked the grout. Questions were asked about the
quality of the grout and if better suited grouts could be used. It was also stated that since the road was not completely closed down, the constant traffic may have induced the cracking of the grout. The use of a ready mix grout was also suggested as that could save time and effort. Moreover since the shear keys were large it was difficult to mix the grout without forming cold joints. Returning to the issue of grout seeping into the PT ducts, the contractor noted that using three holes made it difficult to seal. Suggestion was made to use one oversized hole and use strands as it would yield similar results. The three holes made alignment an issue and so did sealing.

MOT-70

Winning the bid for CLI-730 encouraged the contractor to put in a bid for MOT-70, the only difference being that the construction for CLI-730 was phased. No incentive was marked for this project and the contractor observed that the encouragement to complete this job on time was lacking. In CLI-730, like most other pilot projects, the turn around time for the shop drawing was long; usually more time than necessary. However, in this project the drawings were reviewed and returned early and the work was on schedule. Additional suggestions for ODOT is to either order and purchase the beams early or give out another contract for the beams so that the contractor does not have to wait for the fabrication of the beams. This promotes getting the project off early and since these projects are not design build, the suggestion is worth looking into (although ODOT mentioned that there were possible problems to be encountered). In an effort to speed up the construction, the contractor began working on the MSE (mechanically stabilized earth) walls even before the shop drawing was approved. The problems associated with MSE when not using straight flat ground were talked about. While turning corners and
sorting the piles, there were equipment access problems and ultimately shoveling was done by hand which shot up the price and took longer. The use of CIP (cast in place) walls along with flowable fills as an alternative to the MSE was also suggested.

The use of stands in this project as opposed to CLI-730 was much appreciated. It was easier to put the strands through the sleeves even though more than one strand was pushed through. Also, the metal sleeves were better aligned and made the job easier. The strands were more flexible and it could be twisted through the sleeves unlike the bars which were far too stiff for even slight bending. It was acknowledged that since the beams were made on the same bed, two at a time, the camber did not pose a problem. The lack of belly on the beams also helped in placing the doughnut with a bit of greasing over the PT tubes and it could be firmly sealed without chances of the grout seeping through. The beams were also brought together with a slight bit of pre tensioning on the lateral tendons after the beams appeared to spring back once the come alongs were released. Use of a ready mix grout was suggested as the correct amount is difficult to predict otherwise. The grout seeped from below the bridge while filling up the shear keys. It was felt that the use of something more effective than backer rods could be used to seal it.

Permits issues and the lack proper transport were discussed. There were so few truck that 5 beams were transported to the site every night and the at times the trucks were round-tripping. The contractor would have been pleased if the beams could be stored on the site and set as many beams as possible every night without any constraints. Lighting at the site was felt to be inadequate at times for working in the dark.
Chapter 5

Lessons Learned and Recommendations:

1. Performance based rating system: I suggest the development of a performance based rating system for the contractors. It was observed that a $5000 /per day incentive for early completion is not incentive/disincentive enough for the contractors. A day’s delay would cost them an amount that really has little effect on the contractors. Whereas completing the job on time is imperative for the contracting agency, extending the construction duration brings in numerous intangible costs to the state. One option is to increase the I/D value. However, it often becomes disproportionate to the cost of the project and also the cap on I/D is already determined by the states and not open to change. I am of the opinion that the rating system will encourage the contractor to work well on the project provided that the contractor ratings are pulled up and has a specific percentage influence on future bid processes.

A ten point rating system may be developed with every two points being given to the five different aspects of the construction. For example:

i ) Completion of job on time

ii) Completion of job within budget

iii) Quality of job

iv) Interaction with contracting agency

v) Overall opinion of contractor’s job

Finally the total rating is tabulated and kept aside for future reference. So when the contractor bids for future jobs the rating from the previous job could be pulled up. If the ratings are good then the contractor may have a higher chance of getting the job. This, in addition to the I/D on
the project will act as a major encouragement/discouragement as performance on the project will affect the contractors chances of winning future contracts.

2. Transportation:

Transportation of the huge and heavy precast beams to the construction site was a matter of constant concern for the contractors. The beams were so large that they needed special trucks to haul them. To make matters worse, there were few such trucks in the state which meant that the trucks were often doing multiple trips to get the beams across. The construction schedule was thus heavily dependent on the availability of the trucks. These issues were raised during the post construction meeting for each the projects. A day’s work on Mot-70 was lost because the truck broke down and the highway patrol did not allow the load to be transferred onto another truck. Additionally, these trucks were allowed to travel only during specific times of the day and the permits were quite inflexible. To have the equipment in place and on time is imperative for the success of accelerated construction projects. ODOT was aware of the fact that few trucks were available to transport the beams and special permits must be sought to ensure some degree of flexibility to the trucking company so that construction is not delayed due to transportation problems.

3. Rain Day Rule:

ODOT Rain Day Rule states that a maximum of two hours work must be performed on a rainy day to avail of the rain day benefit. This means that if construction work is disrupted due to rain after more than two hours of construction work, then the contractor does not receive any
consideration. It is hard to imagine the premise on which this rule is structured. The Rain Day Rule proves a huge disincentive for the contractor to work on days where the possibility of rain is high. A simple example: if there is high chance of rain in the afternoon the contractor can work whole morning, but the afternoon’s work which is missed due to rain will not be taken into consideration by ODOT since the contractor has possibly put in more that two hours of work. On fast track/accelerated projects the contractor should be given enough push to get as much work done as possible and not to held back by such archaic rules. One possibility that ODOT might consider in this regard is to extend the two hour limitation for rain delay to four to provide the contractor enough incentive to get as much work done as possible. Another possibility is that the agency could calculate the total number of hours lost to rain. The hours could be tabulated and the contractor should be allowed to extend the construction by the same time. Example: 2 hours of work have been lost for 3 days. Hours lost due to rain equal 6. Considering 8 hour work days the contractor should be asked to adjust or accommodate if there are less than 5 hours lost to inclement weather. For more than 5hrs the contractor should be allowed an extra day.

4. ODOT Role:

Traditionally the contracting agency’s work or involvement on the project ends once the contract is signed and contractor takes it upon itself to provide the constructed product. ODOT often sticks to this attitude and maintains certain degree of aloofness. In a way, the agency distances itself from the construction process hoping that work is done perfectly otherwise of course the legal implications for the contractor. However on such projects where the technique was unfamiliar and the contractors had little to no experience, the contracting agency needs to work closely with the contractor during the entire construction process. I feel that just from the
sheer experience and information at their disposal ODOT would be in a better position to foresee some of the problems that may crop up. So it is in the state’s best interest that ODOT maintains a more involved posture during construction. On Cli-730, ODOT distanced itself from the construction process leaving it to the contractor to figure out. The basic nuances of this type of construction was missed so the end product was far from favorable with the rubber doughnuts moving from their set positions, thereby breaking the sealing on the post tensioning tubes which allowed grout to seep in and disrupted the post tensioning process. Mot-70, which followed the debacle at Cli-730, was much different. ODOT took a more active interest by supervising and offering guidance on the construction work. Construction on this project was up to the mark and on time, much to the satisfaction of both the parties.

5. Flexibility:

On innovative accelerated projects it is important to offer the contractors a greater degree of flexibility. This allows them to be innovative, think creatively and possibly construct quicker and better. Contractors complained that the contract was too detailed with little or no scope to alter anything. The materials list was too detailed, being that ODOT specified each and every material to be used. For example, on Gue-513 the contractor was eager to use a more efficient quick setting grout. ODOT was however unwilling to allow even that change despite the time that would be saved. This brought up the point during the post construction meeting for Guernsey that ODOT’s material list was last updated five years back causing the agency to disregard many newer and more improved materials. Clearly the materials lists need updated yearly to keep up with the new materials being introduced. An ideal solution is for ODOT to
completely do away with the lists to allow contractors flexibility and so that their ideas can be incorporated in the construction process.

6. Design:

Given that the design and construction of the bridges chosen were a first time in the state of Ohio, neither ODOT nor the state contractors were familiar with this innovative design/construction process. This brought to the forefront a set of problems which were different from the ones faced in earlier projects. The choice of subcontractors on the job was almost negligible and thus the project schedule was driven by the availability of subcontractors. This somewhat reduced or marginalized the role of the contractor’s influence on the schedule. The beams—the primary components for construction—were manufactured by the precaster. Construction could begin only after the beams were made available by the precaster and approved by ODOT. Also the quality of beams affected the construction. Camber was an issue on one bridge, the choice of plastic sleeves for the p/t steel, alignment of all the ducts etc. had a considerable effect on the timely construction. This reveals how the contractor basically assumes the role of the assembler: all the components are brought to the site and the contractor just puts them together.

Suggested at the post construction meeting was that ODOT creates a separate contract for manufacturing the beams so that they are ready once the final contract is given out and work can start shortly after. This would be useful for accelerating the project further.

There were only two post tensioning companies in Ohio, one that works with strands and the other with bars. Essentially, only one post tensioning company is available for each type of
job. The availability of the post tensioning company was of paramount importance to the timely completion of the project.

Though the design proved to be innovative, time saving and quite inexpensive the few negatives are the following:

i) A first time design in Ohio. Typical teething problems were encountered.

ii) Even though contractors were willing to take up the challenge there were just one or two subcontractors, leaving the project heavily dependent on their availability.

7. Consistency in Local Jurisdiction:

A matter of concern for the contractors and at times for the designers was the difference in rules and regulations between projects under the different jurisdictions. There is no one set of regulations driving the construction in Ohio as it varies with every project jurisdiction, making it difficult for the contractors to conform to alternating subtleties in rules when working on different projects. This was illustrated when, in one county, the pouring of one approach slab for the bridge is permitted only one at a time, whereas in other counties the contractors can do both at the same time. These are not significant differences in terms of constructability or design but a major hindrance to accelerated construction. Contractors need to constantly keep abreast with the county regulations rather than follow just one clear set of regulations for the state and go ahead with the construction.

8. Contingency plans:

As a matter of practice, ODOT should develop and also encourage the contractor to develop a set of contingency plans to evaluate “what if” scenarios in order to enable both the
agency and the contractor to be better prepared. There are so many different elements that need to fall into place for the successful completion of construction that there is always a high probability of encountering a hitch. It is imperative that these possibilities are explored of and an alternative plan kept handy so as not to delay the construction process at any point in time.

9. Morale:

Morale of the personnel on the construction project is of paramount importance when the project is being accelerated. Problems and setbacks encountered during the process often dampen spirits. The problems and stumbling blocks are should be encountered smoothly, amicably and expeditiously to keep the morale high to maintain a steady pace.

10. Learning process:

There are no fixed formulae for accelerating construction. With every project the process further evolves. This makes it important for people associated with the projects to constantly learn, update and evaluate so that the following project is better executed. Projects are thus a yardstick of the constant learning process that is essential for the success of future projects.

Discussion:

With an ageing transportation system coupled with growing traffic demands every state highway agency has identified a need to accelerate construction. Ohio too has made a positive start to accelerate the construction and rehabilitation of the state highway network. The strategic initiative #9 was a step in that direction. Six bridges under the initiative were constructed using innovative methods, materials and contracts. The contracts used for the four projects that I
studied were design build, A+B and incentive/disincentive. The design build project was major
success and reflected the advantages of the use of this type contract in accelerating construction.
A+B and I/D contracts on the other hand brought to focus the question of the value of I/D
offered. It is important that the value of the I/D in the true sense of the term acts as a
e ncouraging or a discouraging element towards completing the project on schedule. My analysis
of the projects did reveal that the value of the incentive/disincentive used were not a major
source of motivation towards timely completion of the project, which is imperative in an
accelerated project.

The choice of design for rehabilitation did contribute in a positive manner to reduce the bridge
construction downtime. It was a significant departure from the use of cast in place reinforced
concrete decks. The beams were manufactured at the yard, assembled at the site and then post
tensioned to make the separate bridge deck units to function and bear load as one consolidated
unit. This eliminates the time the bridge is down for the concrete to cure, which was the method
followed in traditional construction methods. In short, the use prefabricated bridge decks reduce
traffic congestion, environmental impacts and improves construction zone safety. However, there
were nuances that were critical and at times overlooked. Introducing completely new designs and
construction techniques leads to a level of uncertainty. This can be overcome with an effective
feedback process, attention to detail and an eagerness to learn from mistakes. This was evident
throughout the project.

The SI #9 project introduced with the sole intention of reducing bridge downtime was planned
and executed well. Certain shortcomings were also observed. Better planning, preparation,
sharing information, a more proactive role on the part of the contracting agency could help in
such executing such innovative, accelerated projects with greater success.
Conclusions:

Of the six bridges earmarked for the Special Initiative 9, four were completed successfully (work is due on the remaining two). “Building bridges faster, smarter and better” proved to be an exciting project, a good learning experience for all the agencies involved in the construction and an opportunity to use innovative methods.

Guernsey being the first project had its teething problems, which were worked on during the construction process. Work was interrupted due to the lack of agreement on the type of grout to use and in addition to that the weather was far from perfect for a few days. There were areas of improvement and learning as well as pointers for future projects. Though the work took a couple of days extra to complete, the project was hailed as a success.

Pickaway, which followed the project at Guernsey, was also successfully completed. A design Build project by Ruhlin Construction, it was completed ten days early costing the ODOT an additional $500,000 incentive. Though the cost for this project was a higher than ODOT had expected, the savings were passed on to the Pickaway County in getting a major bridge opened early.

The bridge in Clinton and Montgomery were the third and fourth bridges that we studied. Both built by the same contractor, one was a success and the other not. It was a first time for the contractors on a type of project that is new to the state of Ohio. Cli-730 built before Mot-70 faced numerous problems as the construction went along. The contractors overlooked specific areas that had to be dealt with utmost care and precision and things went wrong. ODOT also adopted an aloof posture that definitely did not work well on the project. Experience gained from the earlier projects should have been passed on to the contractor but that was not the case. Mot-70, on the other hand, was a project executed quite commendably. The contractors backed
themselves up with the experience gained from Cli-730. They were careful and ODOT also took to offering guidance and supervision to avoid any possible roadblocks.

Having observed the construction of four bridges under the Strategic Initiative-9 project, three directly and one obliquely, the following are the summary of the observations I made and possible guidelines for future project.

Need and cost are the two main driving elements for accelerated construction. The contracting agency has to recognize the necessity to accelerate the construction and also budget in, the possible additional initial cost for acceleration.

For state highway agencies like the Ohio Department of Transportation the use of pre fabricated bridge elements are proving to be a very convenient and effective method. Pre fabricated materials and being used extensively around the United States for not only repair and rehabilitation but also construction of entire bridges. These prefabricated bridge elements can be manufactured offsite, under stricter quality control and transported to the site for easy assembly. Use of such materials not only assist in acceleration the bridge construction process but also reduce congestions, environmental impacts and work zone safety and also ensure better quality through consistent quality control measures, improved constructability and possibly lower costs.

However like any other industry, the construction industry too is inflicted by a resistance to change. The use of innovations necessitates breaking away from the traditional methods and wholly and completely adopting to and accepting the changes.

In keeping with the atmosphere of change and innovations ODOT implemented Strategic Initiative # 9, a project implemented to build bridges “faster, smarter and better”. This project was considered a success. This success is was not judged on the basis of how perfect the bridges were built but this project brought to the forefront issues that could help bridges to be built
“even faster, even smarter and even better”. Six bridges chosen under the project used prefabricated bridge elements and post tensioning; a technique not used in Ohio before.

A major issue that was highlighted throughout the project was that of the mind set of people involved with the project in various capacities. The industry with its notoriety of not being open to change had difficulty removing itself from the approach it had harbored for decades to a completely new one for the success of such projects. The contracting agency with its age old policy of distancing itself from the project once the contract is given out proved to be disastrous at times. A lack of involvement till something goes wrong is detrimental for the success of innovative accelerated projects. The projects require if not demand complete involvement of every party associated with the project to plan, exchange ideas and information and to foresee possible areas of difficulty. Moreover the state highway agencies are in a position to assist the construction work from the very beginning given the sheer wealth of information, knowledge and experience at their disposal. Oftentimes the project is a first for the contractor and it has its share of problems, which needs to be countered with greater involvement on the part of the contracting agency.

These innovative construction techniques and methods are being newly implemented. In Ohio the use of post tensioning of bridge decks was a first. Implementation of a technique for the first time demands greater tolerance and an ability to learn from mistakes. Every new project is an experiment and every new project brings to the forefront a new set of problems. So it becomes imperative to take notes from every project and apply them on following projects. On the Strategic Initiative #9, where six bridges were constructed, a definite learning curve was observed. A positive learning curve where lessons learnt from past projects
are applied to future projects is important for the growth and success of innovative construction techniques.
Figure 1: Bridge locations
Figure 2: Guernsey 513 – Bridge elevation
PRECAST MODULAR SLAB LAYOUT

Figure 3: Guernsey 513- Top View of the bridge
Figure 4: Guernsey 513- Longitudinal section.
Figure 5: Guernsey 513 – Bridge Cross Section
Figure 6: Guernsey 513- Placing the beams: lateral P/T ducts are visible

Figure 7: Guernsey 513- Placing the beams: longitudinal P/T ducts are shown
Figure 8: Guernsey 513 - The Bridge
Figure 9: Clinton 730- Placing the beams
Figure 10: Clinton 730-Post Tensioning
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